Technical information **bulletin**

6

Heat transfer fluid maximum temperature ratings

Why temperature ratings are important

Every heat transfer fluid manufacturer assigns a maximum use temperature or maximum temperature rating to each of its fluids. How is this maximum temperature rating determined, and how does this rating relate to the safe and efficient operation of the fluid in a heat transfer system? Answers to these questions are important when selecting a heat transfer fluid for a particular application. The reliability and overall cost of operation of the heat transfer system can be directly related to the fluid's thermal stability, which is the key parameter when determining the maximum temperature rating of the fluid.

What is thermal stability?

Thermal stability is defined as the resistance of a fluid to breakdown (sometimes called thermal degradation) at a given temperature. The rate of thermal degradation is inversely proportional to the level of thermal stability. The greater the amount of thermal degradation, the lesser the thermal stability of the fluid. All organic heat transfer fluids thermally degrade over time. When evaluating thermal stability, the rate of degradation and the types of degradation products are critical considerations.

How is thermal stability measured?

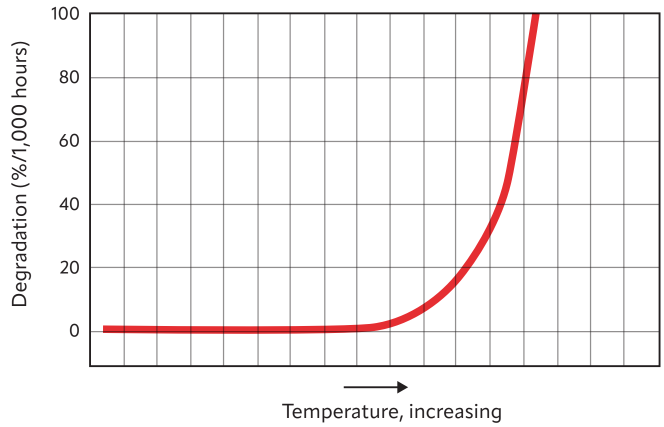
For years, laboratory ampoule studies have been the most common method used by heat transfer fluid manufacturers to determine thermal stability. In this method, a small quantity of fluid is placed in a glass or stainless steel ampoule. The ampoule is purged with nitrogen to remove any residual air and water and then sealed. The fluid-filled ampoule is then held at a constant, elevated temperature for a given period of time, usually 1,000 hours. After this heat stressing, the fluid is analyzed by gas chromatography to measure the total amount of degradation and classify the degradation products as either low boilers or high boilers (these will be discussed in more detail in the next section). This process is repeated at several different temperatures with degradation amounts measured for each. A thermal stability curve comparing measured thermal degradation rate versus temperature can then be generated (Figure 1).

Thermal stability data should be the primary information used in establishing the recommended maximum temperature rating of a fluid. Since the thermal stability curve generated from ampoule tests is very important in determining the maximum use temperature of the fluid, care must be taken to ensure the ampoule tests are done with precision to enhance the accuracy of the results. This data, when interpreted properly, should also support experience gained from the fluid's performance in operating systems at various temperatures.

Relating the fluid degradation data to its operation in a system is critical. Most fluid manufacturers employ ampoule tests to project typical fluid life at a specific operating temperature. However, interpretations of the data generated in such ampoule tests can and do vary, so fluids rated at identical maximum operating temperatures by different manufacturers may not have the same operational life in a system. Even if the same fluid chemistry was measured by different manufacturers, they could get different results because of different interpretations of the thermal stability testing.

Thermal stability ratings have been conservatively established for each Eastman Therminol® heat transfer fluid. Using a conservative approach in setting maximum temperature limits for Therminol fluids means that users can generally expect reliable operation and long fluid lifetimes, even when operating at the maximum temperature rating. With Therminol, there is generally no need to apply an additional safety factor to the maximum temperature rating in normal use situations.

Figure 1. Degradation vs. temperature*



**Note: This information does not constitute an express or implied warranty. See disclaimer on the back of this bulletin.*

How do fluids degrade?

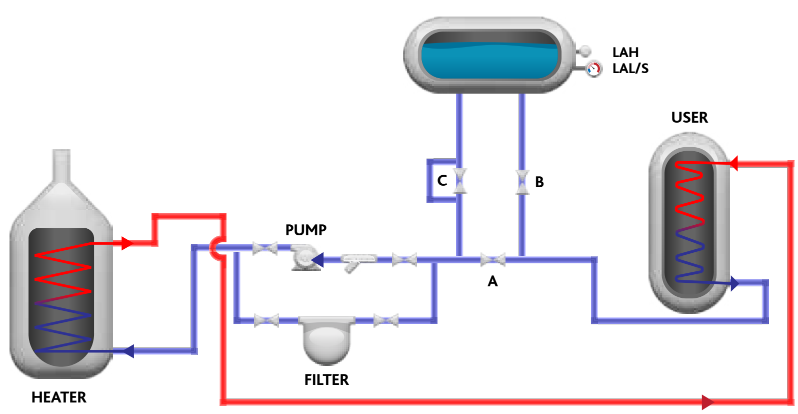
Typically, heat transfer fluids are specific blends of chemical compounds. The chemical composition of a fluid determines thermal stability. When the temperature becomes high enough, the molecular bonds within the chemical structure break to form two main types of degradation products. One class of products produced from this thermal cracking is lower in molecular weight and commonly known as low boilers. Because of their volatility, low boilers can be detrimental to system operations. If low-boiler concentration is allowed to reach excessive levels in the fluid, problems such as pump cavitation, increased system pressure and flash point depression can occur. Intermittent, controlled venting is a common solution to minimize the potential for problems caused by excessive low-boiler concentration. High rates of low-boiler generation caused by poor thermal stability can also result in excessive fluid makeup costs, since the vented low boilers must be replaced with new heat transfer fluid.

High boilers can also be generated by thermal degradation. Some of the low boilers formed in the thermal degradation process polymerize or recombine to produce higher-molecular-weight materials. Since these high-molecular-weight components have a higher boiling point than the original fluid, they cannot be vented from the system. When their concentration reaches an elevated level, typically greater than 10%, the viscosity of the fluid in the system may increase enough to affect fluid pumpability and overall heat transfer efficiency. Extreme levels of high boilers can create sludge and cause system fouling. Eliminating elevated concentrations of high boilers requires fluid replacement, since high boilers cannot be vented or filtered from the system.

Accurate fluid temperature rating is important.

Less than adequate thermal stability will result in high rates of fluid degradation and can have a significant effect on both reliability and overall cost of system operation. Since thermal stability varies with temperature, the fluid manufacturer's recommended maximum temperature rating of the fluid is very important. If the rating is overly optimistic, unacceptable rates of fluid degradation can occur in the heat transfer system even if the fluid is used only within the recommended maximum temperature rating. The user must require that the maximum use temperature recommended by the manufacturer be determined from scientific laboratory testing and extensive real-world experience. If the fluid has been thoroughly evaluated and properly rated, the user should have fewer concerns about its performance in the heat transfer system.

Figure 2. Typical fluid volumes and temperatures*



Heat transfer system section	Typical portion of total volume	Typical fluid temperature
Supply	33%	Bulk heater outlet
Return	33%	Return temperature
Expansion tank	33%	≈93°C/≈200°F, depending on design
Boundary layer in heater coil	1%	Bulk heater outlet + 30°C/50°F, depending on design

**Note: This information does not constitute an express or implied warranty. See disclaimer on the back of this bulletin.*

All Therminol heat transfer fluids undergo multiple evaluations in our testing laboratory to accurately assess their thermal stability. These results are then correlated with years of real-world customer performance history. Users have found that Therminol heat transfer fluid operated in a heat transfer system at or below the recommended maximum bulk and film temperature provides many years of trouble-free performance.

How does the temperature profile within a heat transfer system affect fluid performance?

In most industrial heat transfer systems, the heat transfer fluid is exposed to a variety of different temperatures. These temperatures can vary widely in various parts of the system during normal operation. Eastman offers heat transfer fluid users and system designers recommendations for both the maximum bulk and film temperature for each Therminol heat transfer fluid. Maximum bulk temperature is the temperature of the fluid as it exits the heater. The maximum film temperature is defined as the fluid temperature in the boundary layer at the heat input surface. In a typical well-designed and operated system, the film temperature is usually 25°–30°C (45°–55°F) higher than the bulk temperature (though this can vary depending on heater design). In a typical system, approximately 1% of the fluid volume is in the boundary layer where it is exposed to this elevated temperature. Fluid contained in the expansion tank and the process return piping is typically exposed to significantly lower temperatures than the supply stream and, therefore, has much lower thermal degradation rates. Using the thermal stability curve generated from laboratory ampoule data, fluid degradation can be estimated for each part of an operating system. Low- and high-boiler formation for the total fluid charge can then be calculated and an estimate made for the fluid life in a given system.

What affects maximum fluid life?

For most systems, thermal stability at a system's operating temperature is the most important factor in establishing the operating life of a heat transfer fluid. As discussed above, lower thermal stability will result in greater degradation. At or near the maximum recommended use temperature of the fluid, small changes in temperature have a large impact on the rate of thermal degradation. When operating a heat transfer fluid at or near the maximum use temperature, increasing the temperature 10°C (18°F) will roughly double the rate of thermal degradation. Conversely, the fluid degradation rate is roughly cut in half for every 10°C (18°F) decrease in fluid operating temperature when operating at temperatures at or near the maximum use temperature. Therefore, care should be taken in the design and operation of the system to minimize the possibility of overheating the fluid.

Operational problems, such as low fluid velocity in the heater leading to a loss of turbulent flow or flame impingement on the heating surfaces within the heater, can increase fluid temperature very quickly. Unless such problems are quickly and effectively corrected, accelerated and irreversible thermal degradation can occur. To maximize fluid life in a heat transfer system, the user should select a fluid rated for the system's maximum operating temperature and then make sure the design parameters and operational conditions of the system minimize the risk of overheating.

Fluid overheating is not the only cause of reduced fluid life. Fluid contamination and fluid oxidation are also detrimental to fluid performance. Oxidation of organic heat transfer fluids occurs at elevated temperatures, usually above 175°C (350°F), and can accelerate the thermal fluid degradation process. Contamination of the fluid from process materials or other compounds inadvertently added to the system can greatly reduce fluid life. System design and operating practices should include measures to prevent the potential oxidation or contamination of the fluid.

Cost performance and reliability

A heat transfer fluid with high thermal stability reflected by an accurate and proven maximum temperature rating can provide excellent reliability and positive cost performance in a properly operated heat transfer system. The initial price of the fluid is often the smallest component of the total cost of owning and operating the heat transfer fluid system. High-cost events such as frequent fluid replacements, sludge removal and system downtime are often the result of the selection and use of the wrong heat transfer fluid. Because thermal stability test data is subject to varying interpretations, such high-cost events can occur even if the heat transfer fluid is used at or below the maximum use temperature if the maximum use temperature has been set too high. The temperature rating for the fluid must provide the user with confidence that the fluid will perform at that rated temperature for a long period of time. Therminol heat transfer fluids are thoroughly evaluated for thermal stability and assigned conservative maximum operating temperature ratings that contribute to long fluid life and optimum cost performance in the user's heat transfer system. Decades of use in thousands of heat transfer systems around the world have proven the reliability and efficiency of Therminol heat transfer fluids.

EASTMAN

Eastman Corporate Headquarters
P.O. Box 431
Kingsport, TN 37662-5280 U.S.A.

U.S.A. and Canada, 800-EASTMAN (800-327-8626)
Other locations, +(1) 423-229-2000

eastman.com/locations